Appendix G
WATER QUALITY

WATER QUALITY PARAMETER MAPS

The distribution of total chloride (mg/L) in the Floridan Aquifer System (FAS) in the Kissimmee Basin (KB) Planning Area is displayed in **Figure G-1**. The distribution of total dissolved solids (mg/L) in the FAS in the KB Planning Area is displayed in **Figure G-2**.

WATER QUALITY STANDARDS

Drinking Water Standards

Current Florida Department of Environmental Protection (FDEP) primary and secondary drinking water standards are shown in **Tables G-1** through **G-3**. Primary drinking water standards include contaminants which can pose health hazards when present in excess of the maximum contaminant level (MCL). Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters that may impart an objectionable appearance, odor or taste to water, but are not necessarily health hazards.

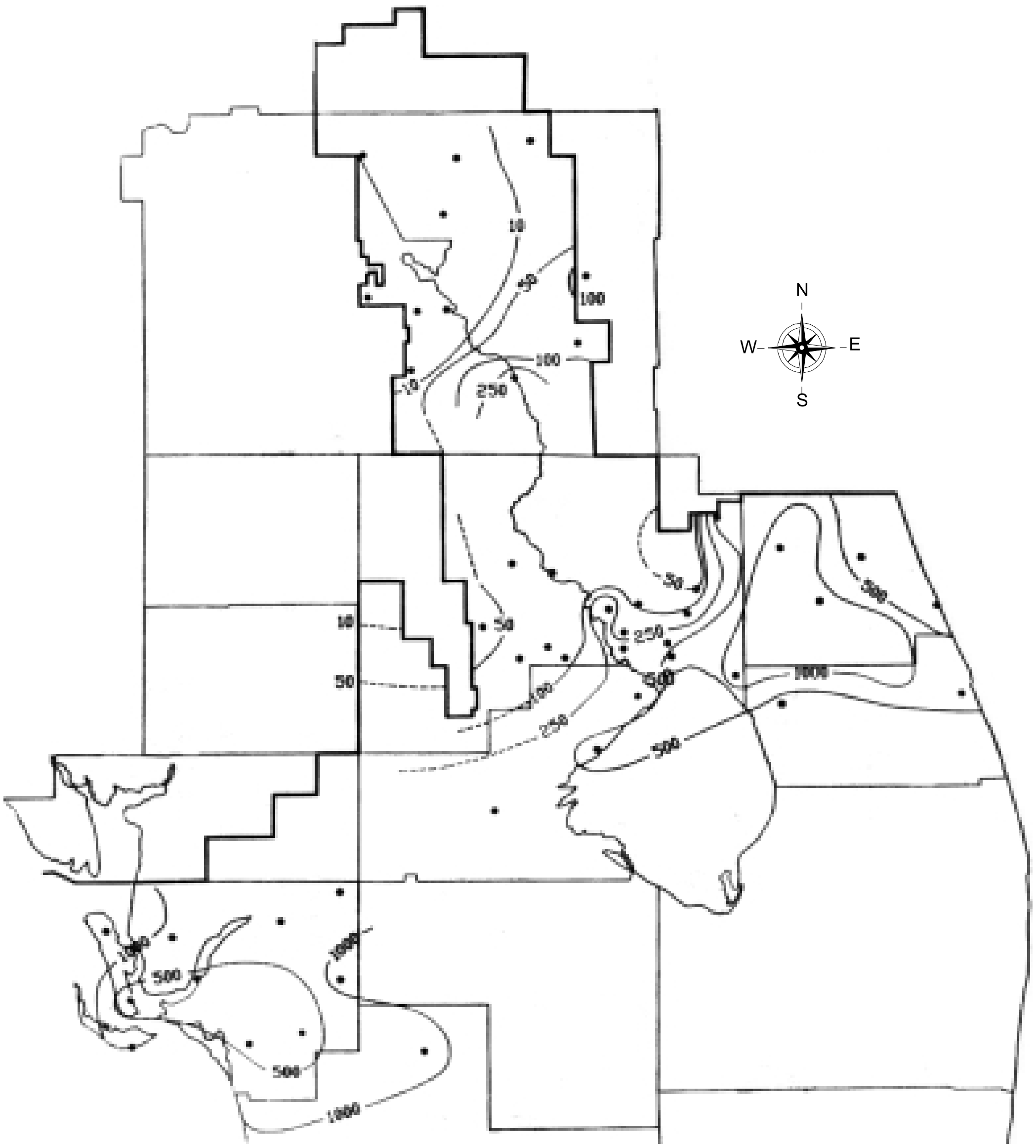

Figure G-1. Distribution of Total Chloride (mg/L) in the Floridan Aquifer System, Kissimmee Basin Planning Area (FGS, 1992).

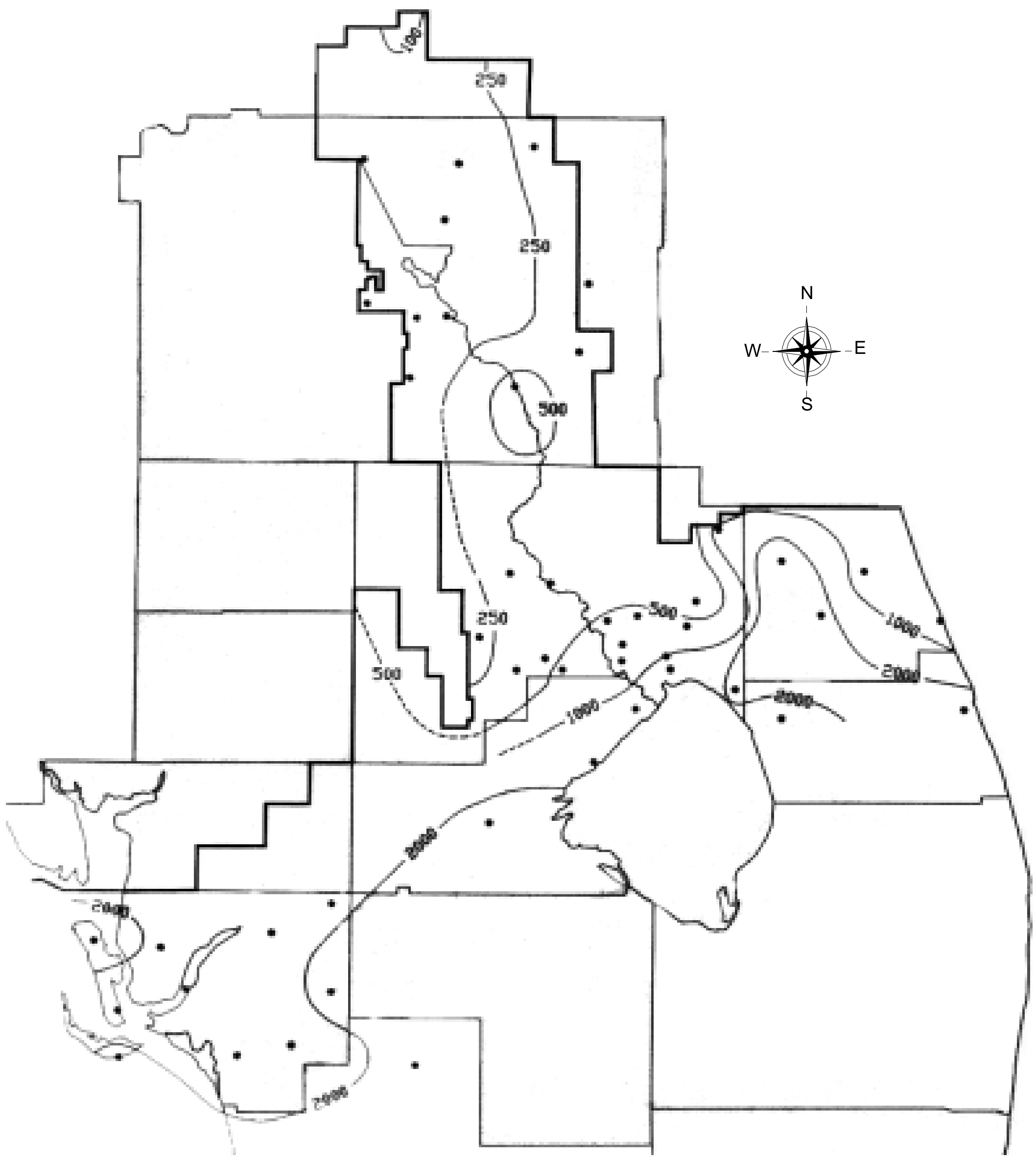

Figure G-2. Distribution of Total Dissolved Solids (mg/L) in the Floridan Aquifer System, Kissimmee Basin Planning Area (FGS, 1992).

Table G-1. FDEP Primary Drinking Water Standards (Chapter 62-550, F.A.C., revised November 22, 1999).

ORGANICS	MCL* (mg/L)
Volatile Organics	
Vinyl chloride	0.001
Benzene	0.001
Carbon tetrachloride	0.003
1,2-Dichloroethane	0.003
Trichloroethylene	0.003
para-Dichlorobenzene	0.075
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.2
cis-1,2- Dichloroethylene	0.07
1,2-Dichloropropane	0.005
Ethylbenzene	0.7
Monochlorobenzene	0.1
o-Dichlorobenzene	0.6
Styrene	0.1
Tetrachloroethylene	0.003
Toluene	1
trans-1,2-Dichloroethylene	0.1
Xylenes (total)	10
Dichloromethane	0.005
1,2,4-Trichlorobenzene	0.07
1,1,2-Trichloroethane	0.005

Total Trihalomethanes

The sum of concentrations of bromodichlormethane, dibromochloromethane, tribromomethane (bromoform), and trichloromethane (chloroform).

PESTICIDES & PCBS	MCL* (mg/L)
2,3,7,8- TCDD (Dioxin)	3×10^{-8}
Alachlor	0.002
Atrazine	0.003
Carbofuran	0.04
Chlordane	0.002
Dibromochloropropane (DBCP)	0.0002
2,4-D	0.07
Endrin	0.002
Ethylene dibromide (EDB)	0.00002
Heptachlor	0.0004
Heptachlor epoxide	0.0002
Lindane	0.0002
Methoxychlor	0.04
Polychlorinated biphenyl (PCB)	0.0005
Pentachlorophenol	0.001
Toxaphene	0.003
2,4,5-TP (Silvex)	0.05
Dalapon	0.2
Di(2-ethylhexyl)phthalate	0.006
Di(2-ethylhexyl)adipate	0.4
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Glyphosate	0.7
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Oxamyl (vydate)	0.2
Benzo(a)pyrene	0.0002
Picloram	0.5
Simazine	0.004

INORGANICS	MCL* (mg/L)
Contaminant	
Antimony	0.006
Arsenic	0.05
Asbestos	7 MFL**
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Cyanide	0.2
Fluoride	4.0***
Lead	0.015
Mercury	0.002
Nickel	0.1
Nitrate	10 (as N)
Total Nitrate and Nitrate	10 (as N)
Nitrite	1 (as N)
Selenium	0.05
Sodium	160
Thallium	0.002

TURBIDITY

Surface Water

- 1 turbidity unit (NTU) when based on a monthly average.
- 5 NTU when based on an average for two consecutive days.

Ground Water

- 1 NTU

MICROBIOLOGICAL

Coliform Bacteria

- Presence/Absence

Escherichia coli

- Presence/Absence

Giardia lamblia

- Presence/Absence

Cryptosporidium

- Presence/Absence

RADIONUCLIDES	MCL*
- Combined radium-226 and radium-228	5 pCi/L
- Gross alpha activity, including radium-226, but excluding radon and uranium	15 pCi/L
- Manmade radionuclides	4 millirem/yr
- Tritium/total body	20,000 pCi/L
- Strontium-90/bone marrow	8 pCi/L

*MCL = maximum contaminant level.

**MFL = million fibers per liter >10 micrometers.

***Fluoride also has a secondary standard.

Table G-2. FDEP Secondary Drinking Water Standards (Chapter 62-550, F.A.C., revised November 22, 1999).

Contaminant	MCL (mg/L)[a]
Aluminum	0.2
Chloride	250
Color	15 color units
Copper	1
Fluoride	2.0
Foaming Agents	0.5
Iron	0.3
Manganese	0.05
Odor	3[b]
pH (at collection point)	6.5-8.5
Silver	0.1
Sulfate	250
Total Dissolved Solids	500[c]
Zinc	5
Total Trihalomethanes	0.10

a. Except color, odor, corrosivity, and pH.
b. Threshold odor number.
c. May be greater if no other MCL is exceeded.

Table G-3. MCLGS and MCLS for Disinfection By-products (Federal Register, 40 CFR, December 1998).

Disinfection By-products	MCLG (mg/L)	MCL (mg/L)
Total Trihalomethanes (TTHM)[a]	N/A[b]	0.080
Chloroform	0	
Bromodichloromethane	0	
Dibromochloromethane	0.06	
Bromoform	0	
Haloacetic acids (five) (HAA5)[c]	N/A[b]	0.060
Dichloroacetic acid	0	
Trichloroacetic acid	0.3	
Chlorite	0.8	1
Bromate	0	0.010

a. Total Trihalomethanes is the sum of the concentrations of chloroform, bromodichloromethane, dibromchloromethane, and bromoform.
b. Not available because there are no individual MCLGs for TTHMs or HAAs.
c. Haloacetic acids (five) is the sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids.

Irrigation Water Quality Parameters

Chemical parameters of an irrigation water that affect plant growth, yield, and appearance, soil conditions, and the ground water quality governs the applicability of a water. The University of California Cooperative Extension Service has developed a useful and widely accepted guide to evaluate the suitability of an irrigation water and identifying potential areas of concern. Problems and related constituents include salinity, permeability, specific ion toxicity (sodium, chloride, boron), nitrogen, bicarbonate, and pH. These guidelines can be found in “Water Treatment Principles and Design” (J.M. Montgomery Consulting Engineers, 1985).

In addition to these guidelines, recommended maximum concentration for trace elements have been developed and can be found in J.M. Montgomery Consulting Engineers, 1985.

Salinity

Salinity is a measure of the soluble salts, or the ionic activity of a solution in terms of its capacity to transmit current, in a water and is determined by measuring the water's electrical conductivity (EC) or specific conductance. Water salinity is the most important parameter in determining the suitability of water for irrigation. As salinity increases in irrigation water, the probability for certain soil, water, and cropping problems increases. There are several dissolved salts found in water, the principal salts being the chloride and sulfate salts of sodium, calcium, and magnesium (Augustin et al., 1986). Many salts, such as nitrogen, phosphorus, calcium, and potassium are necessary for normal plant growth.

Salt is added continuously via the irrigation water to the soil. Over time, a salinity problem to the plant may occur if the accumulated soil salt concentration increases to where it is harmful to the plant. The accumulation is dependent on the quantity of salt applied and the rate at which salt is removed by leaching. Leaching is essential to successfully irrigate with highly saline water. To assure that salt leaching occurs, additional irrigation water could be applied. Establishment of a net downward movement of water and salts is the only practical way to manage a salinity problem. In addition, under these circumstances, good drainage and/or percolation is essential in allowing movement of the water and salt below the root zone. The climate in an area also affects soil salt accumulation. Evaporation and transpiration remove water and leave the salts behind. Climate also influences the salt tolerance of plants, which will be discussed later.

Ground water salt content increases due to upconing or saline water intrusion. For reclaimed water, salts enter the wastewater stream in many different ways. Salts are contained in drinking water, are introduced through domestic and industrial activities, through water softeners, and through infiltration and inflow (I/I) into the wastewater collection system. Infiltration is where ground water enters the collection system through defective joints, cracked and broken pipes and manholes, whereas inflow is where storm water enters the collection system through combined sewers, manhole covers, foundation drains and roof drains. In coastal areas, I/I of seawater can be major source of salts in the reclaimed water. The advanced secondary wastewater treatment process has little effect on removal of salts from the wastewater stream.

Knox and Black (n.d.) provide a table indicating the degree of salt tolerance of many of the landscape plants adapted to South Florida, including trees, palms, shrubs, ground covers, and vines. Many of the salts are necessary for healthy plant growth; however, excessive concentrations of these salts can have a negative impact on the plant. Salts affect plant growth by: (1) osmotic effects, (2) specific ion toxicity, and (3) soil particle dispersion.

Osmotic Effects

Osmosis is the attraction of dissolved salts which causes water to move from areas of low salt concentration to areas of high salt concentration. Roots selectively absorb compounds that the plant needs to grow. The normal osmotic flow causes water to move from the soil, which is usually an area of low salt concentration, into the roots which is an area of higher salt concentration. Excessive salts in the soil can reverse the normal osmotic flow of water into the plant by reversing the salt concentration gradient, thus causing dehydration of the plant. Increased plant energy is also needed to acquire water and make biochemical adjustments necessary to survive, which will decrease plant growth and crop production. In addition, osmotic effects indirectly create plant nutrient deficiencies by decreasing the nutrient absorption. The salt tolerance of common turf grass species in South Florida can be found in “Saline Irrigation of Florida Turf grasses” (Augustin et al., 1986).

Deposition of salts on foliage through spray irrigation may also cause problems, especially to sensitive ornamental plants. Much work has been devoted to quantify the tolerance of many of the plants. Many researchers have identified the salt tolerance of plants through field observation and have categorized them as having poor, moderate, or good salt tolerance. Several of their publications are available from the Florida Cooperative Extension Service Institute of Food and Agricultural Sciences (IFAS).

Specific Ion Toxicity. Ion toxicity is due to excessive accumulations of specific ions in a plant that result in damage or reduced yield. Toxicity problems may or may not occur in the presence of a salinity problem. Specific ions of concern include boron, chloride, sodium, and bicarbonate. Ion toxicity potential is increased in hot climates. The ions can be absorbed by the plant through the roots or the foliage, but with sprinkler irrigation, sodium and chloride frequently accumulates by direct adsorption through the leaves. Such toxicity occurs at concentrations that are much lower than toxicity caused by surface irrigation. Toxicity associated with overhead sprinkling is sometimes eliminated with night irrigation when lower temperatures and higher humidity exists. Tolerances of these ions vary from plant to plant.

Sodium. Sodium is not considered essential for most plants; however, it has been determined that sodium does positively affect some plants lower than the salt tolerance threshold. The amount of sodium is of concern because it is usually found in the largest amount. Sodium directly and indirectly affects plants. Direct affects of sodium toxicity involves the accumulation of this ion to toxic levels, which is generally limited to woody species (Maas, 1990). Indirect effects resulting from sodium toxicity include nutritional imbalance and impairment of the physical conditions of the soil. Sodium can affect the plant's uptake of potassium. Ornamental sodium toxicity is characterized by burning of the outer leaf edges of older leaves and progresses inward between the veins as severity increases. Sodium is usually introduced into the wastewater stream by I/I. With adequate care, sodium toxicity should not be a problem.

Chloride. Chloride is an essential micro nutrient for plants and is relatively nontoxic. Most nonwoody crops, such as turf grass, are not specifically sensitive to chloride. However, many woody, perennial shrubs and fruit tree species are susceptible to chloride toxicity. In addition, chloride contributes to osmotic stress. Ornamentals express chloride toxicity by leaf burn starting at the tip of older leave and progressing back along the edges with increasing severity. Chloride is usually introduced into the wastewater stream by I/I. With adequate care, chloride toxicity should not be a problem except possibly for irrigation of salt sensitive plants.

The City of St. Petersburg investigated the effect of reclaimed irrigation water on the growth and maturation of commonly used ornamental plants and trees in the St. Petersburg area. The study, called “Project Greenleaf” was also used to determine the chloride tolerance of those plants and trees (Parnell, 1987). The study suggested a chloride threshold of 400 mg/L be established for reclaimed water that is utilized for green space irrigation. This threshold protects salt sensitive ornamentals from the effects of chlorides, which generally have a lower salt tolerance than turf grasses.

Boron. Boron is an essential element to plants but can become toxic when concentrations of soil water slightly exceed the amount required for optimum growth. Boron is usually not a problem to turf grasses because boron accumulates in the leaf tips, which are removed by mowing; however, other landscape plants may be more sensitive to boron levels. Boron toxicity may be expressed by leaf tip burn or marginal burn accompanied by chlorosis of the interveinal tissue. Boron is commonly introduced to the wastewater stream from household detergents or from industrial discharges.

Water Infiltration Rate

In addition to other concerns with high sodium content, it can lead to deterioration of the physical condition of the soil by formation of crusts, water logging and reducing the soil permeability and nutritional problems induced by the sodium. An excess of sodium in the soil could displace nutrients such as calcium, iron, phosphorus, and magnesium from the soil particles and thereby creating a nutritional deficiency that the plant requires in addition to creating soil permeability problems (Knox, n.d.). Infiltration problems occur within the top few inches of the soil and is mainly related to the structural stability of the surface soil and is related to a relatively high sodium or very low calcium content in this zone or in the irrigation water. Reclaimed water usually contains sufficient amounts of both salt and calcium, such that dissolving and leaching of calcium from the surface soil is minimized.

Salt Levels in Soil

Good drainage is essential to leach soluble salts through the soil profile. To maintain a certain soil salt level, irrigation rates exceeding evapotranspiration are required to leach excess salts through the soil.

Salt Tolerance of Plants

Research has found that salt tolerance of plants usually relates to its ability to: (1) prevent absorption of chloride and sodium ions, (2) tolerate the accumulation of chloride or sodium ions in plant tissue, or (3) tolerate osmotic stress caused by soil or foliar salts. Plant tolerance to salts can be influenced differently based on the age of the plant, the stage of growth, irrigation management, and soil fertility. In addition, some plants are tolerant to soil salts but intolerant to salt deposits on the foliage, or vice versa.

The salt tolerance of plants varies greatly. Some plants avoid salt stress by either excluding salt absorption, extruding excess salts, or diluting absorbed salts. Other plants adjust their metabolism to withstand direct or indirect injury. Most plants utilize a combination of these. Turf grass salt stress is indicated by faster wilting than normal due to the osmotic stress, shoot and root growths are reduced to direct and indirect salt injury, leaf burn, general thinning of the turf and ultimately turf death. Landscape plant salt stress could be expressed by burning of the margins or tips of leaves followed by defoliation and death of salt sensitive plants.

Salt tolerance depends on many factors, conditions, and limits including type of salt, crop growing conditions, and the age and species of the plant. The type and purpose of the plant needs to be considered when evaluating salt tolerance. For example, for edible crops, yield is of primary importance and salt tolerance would be based on growth and yield. However, to establish permissible levels of salinity for ornamental plant species, the aesthetic characteristic of the plant is more important than its yield. The loss or injury of leaves due to salt stress is unacceptable for ornamentals, even if growth is unaffected. Accordingly, landscape plants can tolerate relatively higher levels of salts, since reduced growth and yield are the initial effects of excess salts and appearance of plants is not immediately affected (Knox and Black, n.d.).

Climate is a major factor affecting salt tolerance. Most crops can tolerate greater salt stress if the weather is cool and humid rather than hot and dry. Rainfall also reduces salinity problems by diluting salt concentration and enhancing leaching by adding additional water. Nighttime irrigation reduces foliar absorption and injury. In addition, some plants may be tolerant to soil salinity but are not tolerant to salt deposition on the leaves and vice versa. Use of an irrigation technique that applies water directly to the soil surface rather than on the leaf surfaces is preferred when using irrigation water which contains excessive salts.

Nutrients

Reclaimed water contains nutrients that provide a fertilizer value to the crop or landscape, which when accounted for, can reduce the amount of fertilizer applied, thus reducing fertilizer costs. The nutrients found in reclaimed water occurring in quantities important to agriculture and landscape management include nitrogen and phosphorus, and occasionally potassium, zinc, boron, and sulfur.

Municipal wastewaters usually contain sufficient amounts of micro nutrients to prevent deficiencies. The trace elements of boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), sodium (Na), and chlorine (Cl) are essential for plant growth; however, intake of excessive concentration of these elements can be toxic and detrimental to some plants.

REFERENCES CITED

Augustin, B.J., A.E. Dudeck, and C.H. Peacock. 1986. *Saline Irrigation of Florida Turfgrasses*. Circular 701. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

South Florida Aquifer Storage and Recovery Work Group. 1993. Guidance for Development of Class V Aquifer Storage and Recovery Injection Well Systems in South Florida – November 1993. USEPA, FDEP, and SFWMD. n. pag.

Camp Dresser & McKee. 1989. Wastewater Reuse System Engineering Cost Model. Documentation, User’s Guide and Computer Program. Prepared for the South Florida Water Management District, West Palm Beach, FL. vari. pag.

Camp, Dresser & McKee. 1990. City of Boca Raton, Florida, Reclaimed Water System Master Plan. CD&M, Fort Lauderdale, FL.

Eingold, J.C. and W.C. Johnson. n.d. St. Petersburg's Wastewater Reclamation and Reuse Project -- Eight Years Later. City of St. Petersburg, FL. 7 pp.

ENR Engineering News Record. 1994. Construction Cost Index. *The McGraw-Hill Construction Weekly,* 232 (13): 49 and (18): 114.

Florida Geologic Survey. 1992. *Florida's Ground Water Quality Monitoring Program: Background Hydrogeochemistry.* Publication No. 34. FGS, Tallahassee, FL. 364 pp.

Hunter, R.G. 1990. In: *Florida: State of the Environment-Reuse of Reclaimed Water. Florida Department of Environmental Regulation*, Tallahassee, FL. 8 pp.

J.M. Montgomery Consulting Engineers. 1985. Water treatment principles & design. New York: John Wiley & Sons.

KPMG Peat Marwick. 1992. Reclaimed water user cost study. Final report submitted to the South Florida Water Management District, SJRWMD, and SWFWMD. KPMG Peat Marwick, Vienna, VA.

Knox, G.W. n.d. Management of saline irrigation water in the nursery. Circular 718. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

Knox, G.W. and R.J. Black. n.d. Salt tolerance of landscape plants in South Florida. Circular 756. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

Maas, E.V. 1990. *Crop Salt Tolerance in Agricultural Salinity Assessment and Management*. New York: ASCE.

Metcalf & Eddy, n.d. Project Log-Orange County & City of Orlando, Florida, water reclamation facilities. Metcalf & Eddy Services, Inc., Winter Garden, FL.

Parnell, R. 1987. Project Green Leaf - Executive Summary. St. Petersburg, FL.

Schnelle, J.F. and C.C. Ferraro. 1991. Integrated, created and natural wetland systems using wastewater. Presented at: Florida Association of Environmental Professionals Annual Seminar in Jupiter, FL. Environmental Management & Engineering, Palm Beach Gardens, FL. and FDER, Orlando, FL.

University of Florida. 1988. Population estimates for Florida cities and counties. Unpublished data. Bureau of Economic and Business Research, UF.

University of Florida. 1989. Agricultural commodity report. Cooperative Extension, Institute of Food and Agricultural Sciences, Naples, FL. 2 pp.

University of Florida. 1990. IFAS citrus/wildlife study task. Report numbers 1.2.1, 1.2.2, 1.2.3, 1.3, and 1.4. Institute of Food and Agricultural Sciences and the Florida Cooperative Research Unit, UF. Prepared for the South Florida Water Management District, West Palm Beach, FL. Multi volumes.